Biomimetic Acoustic Sensors

Ronald N. Miles
Department of Mechanical Engineering
State University of New York
Binghamton, NY

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
24 AUG 1999	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Biomimetic Acoustic Sensor	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **State University of New York, Binghampton, NY**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
DARPA, Air-Coupled Acoustic Microsensors Workshop held on August 24 and 25, 1999 in Crystal City, VA., The original document contains color images.

14. ABSTRACT

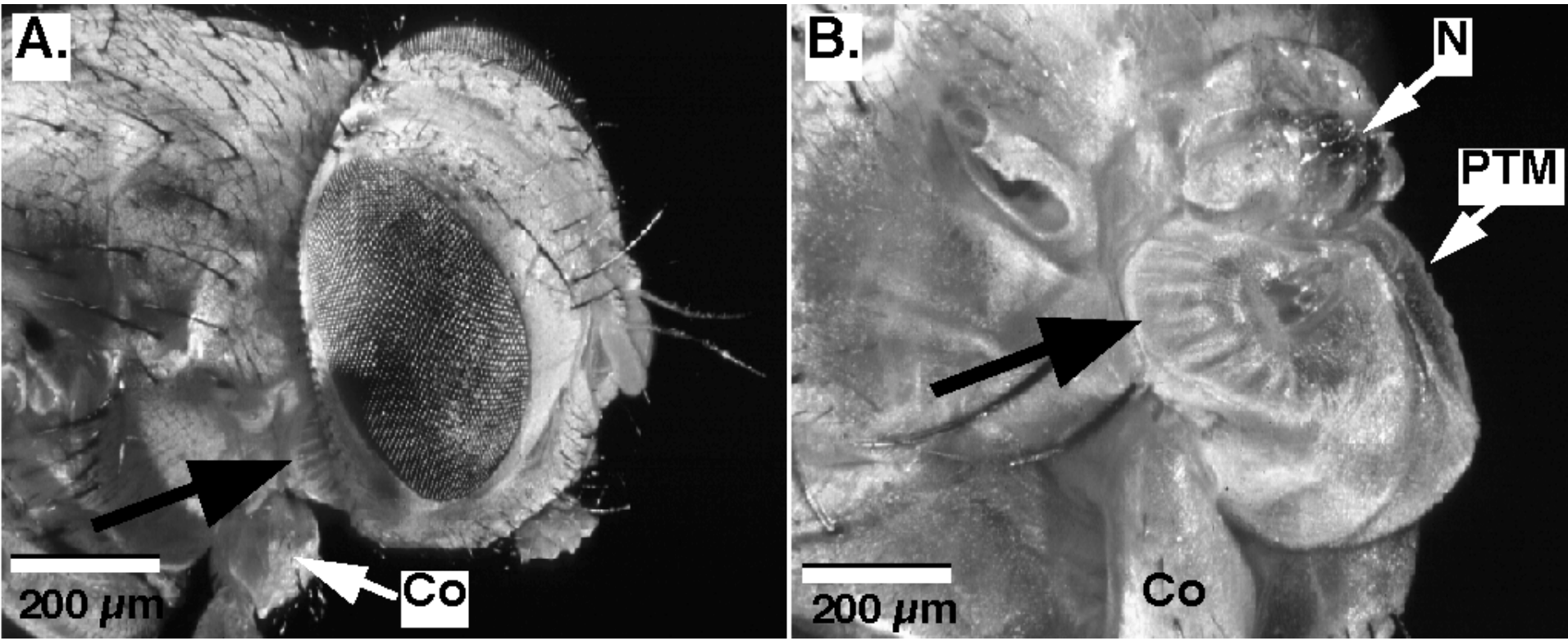
15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**25**	

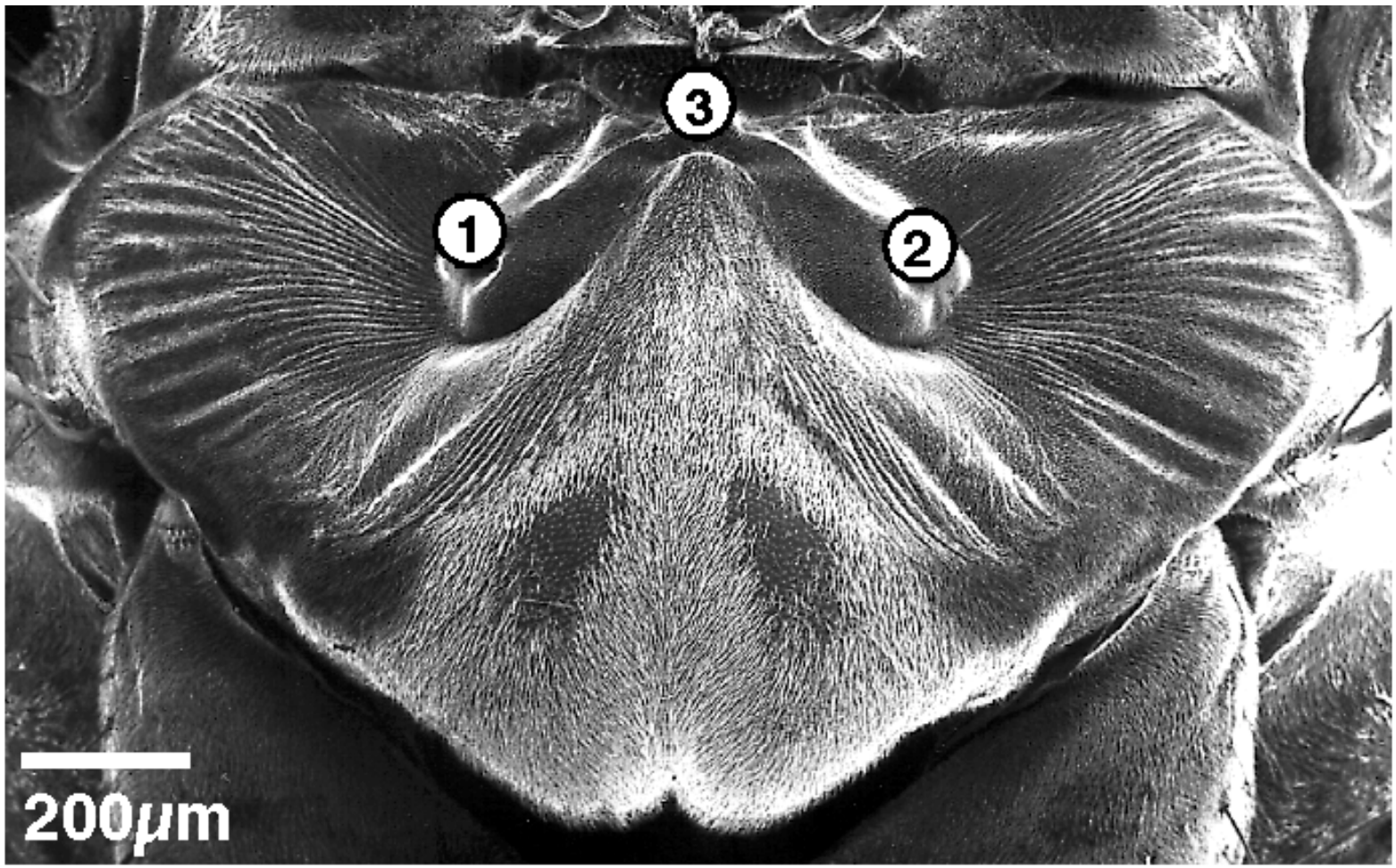
Outline

- Mechanically coupled ears in a parasitoid fly: Novel mechanism for directional hearing
- Biomimetic microphone for hearing aids
- Directional vibration sensing in a treehopper

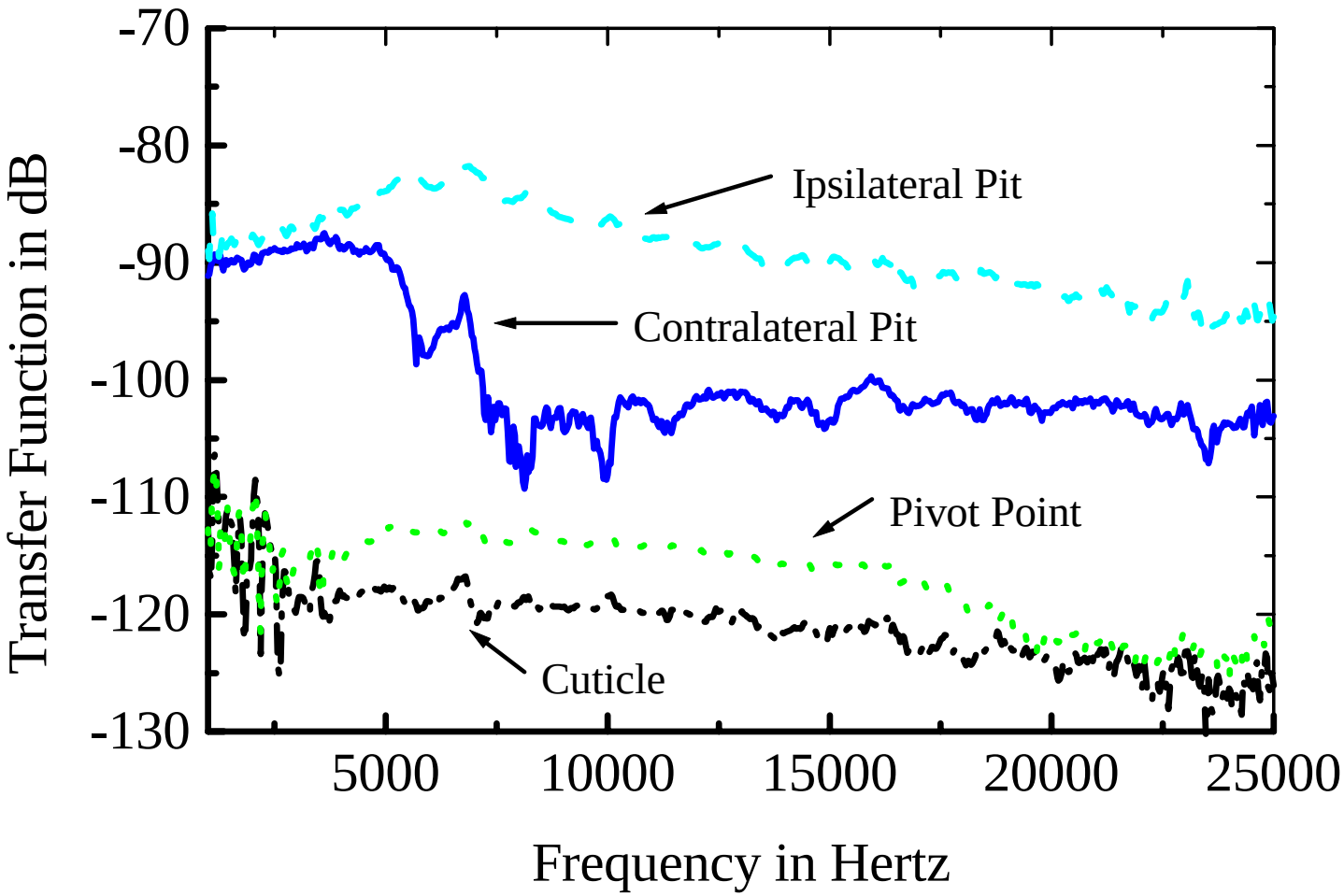
External Anatomy of the Fly's Ears



External Anatomy of the Fly's Ears



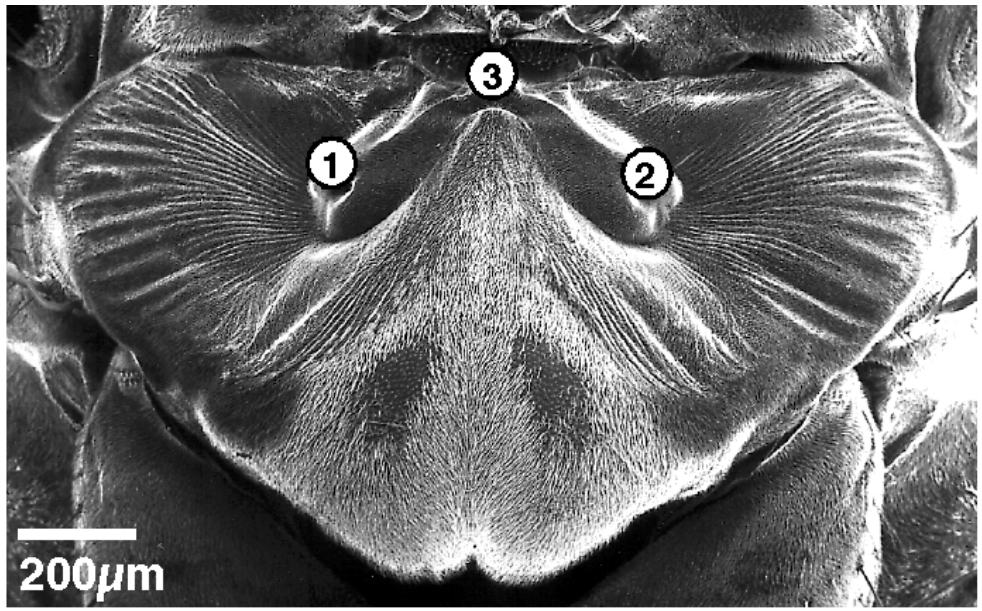
Measured Response is Highly Directional

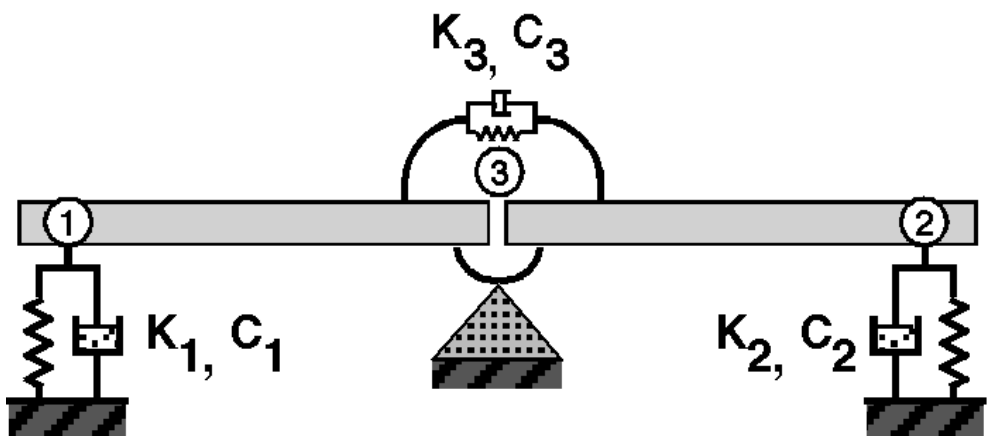


Female Ear Response

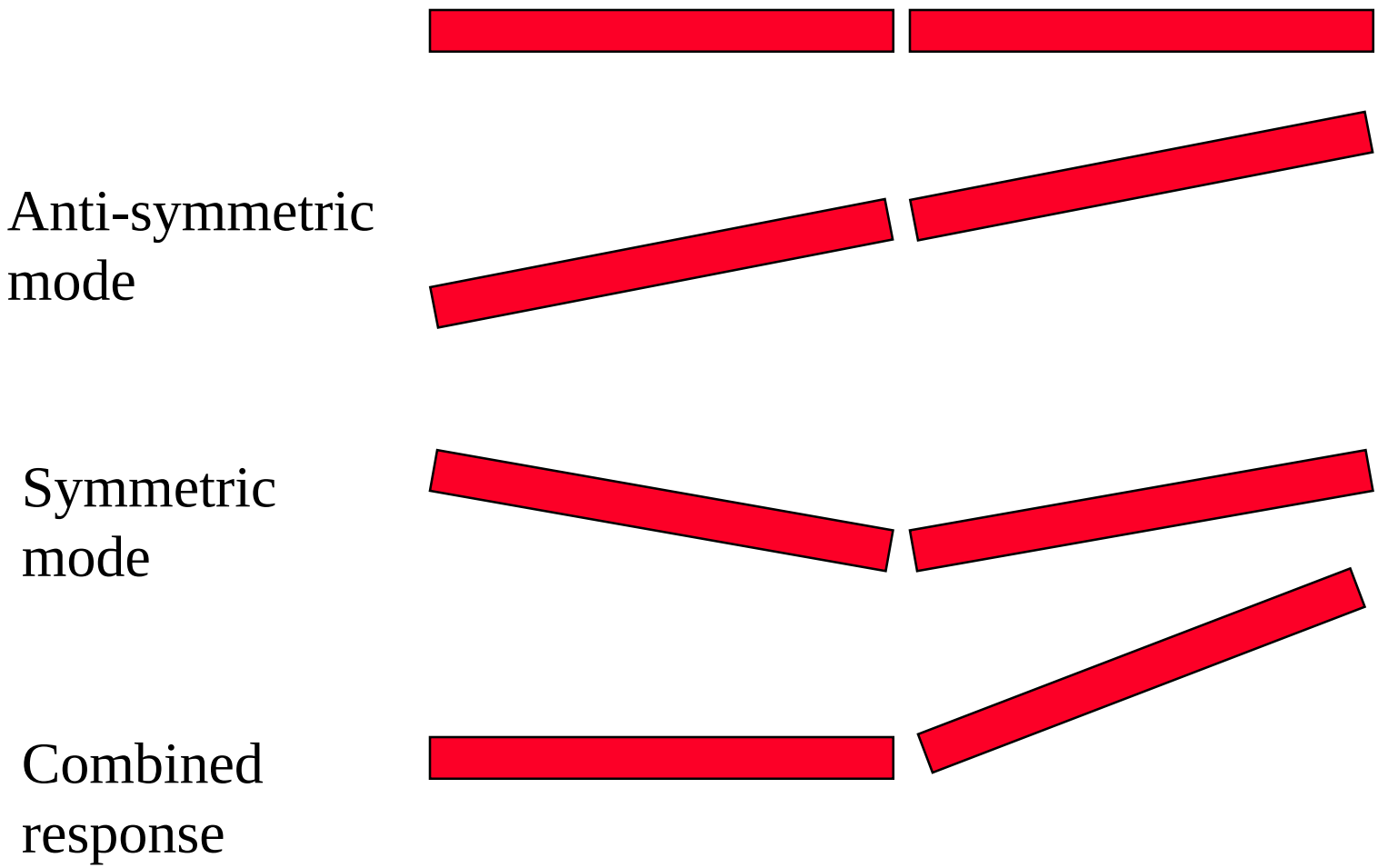
fig 3

Mechanical Model of the Fly's Ears

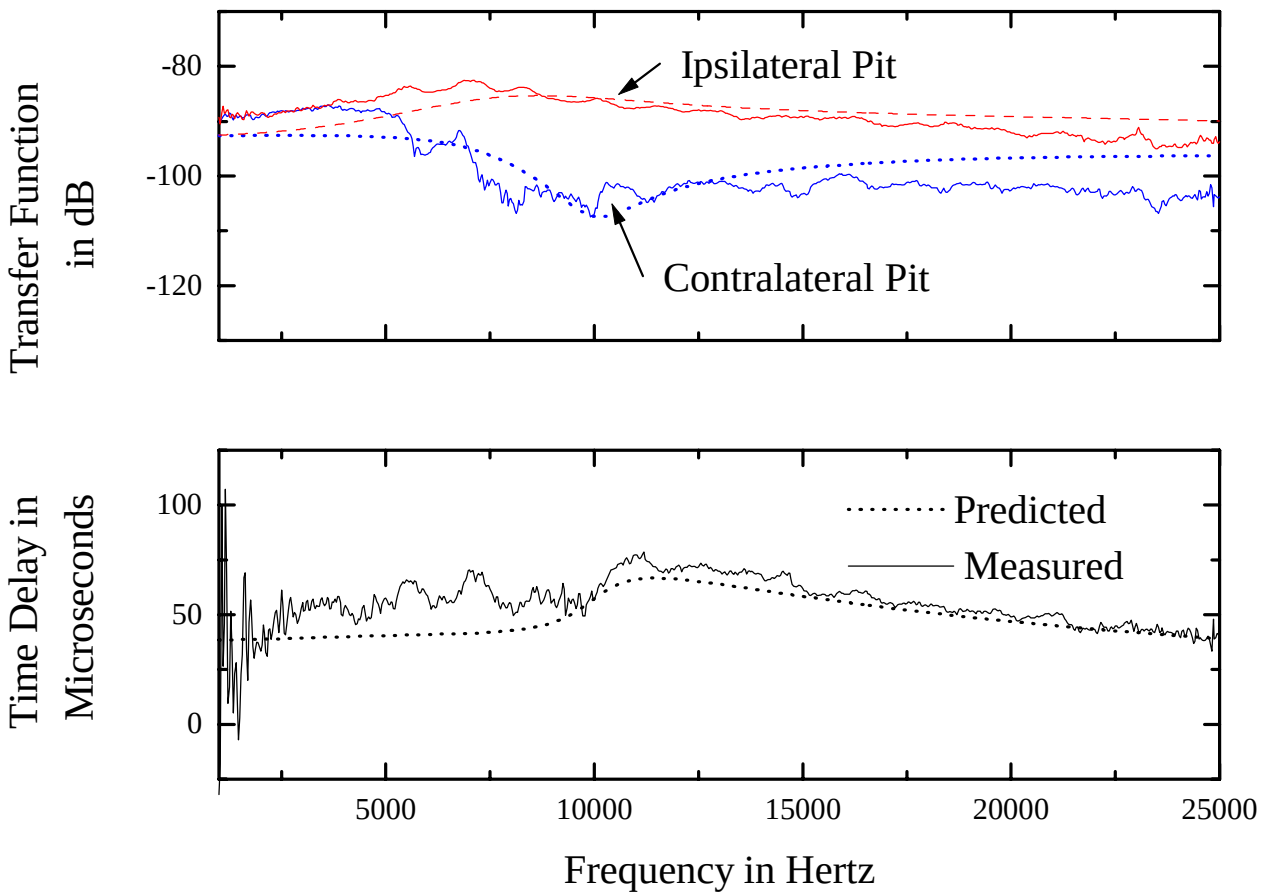




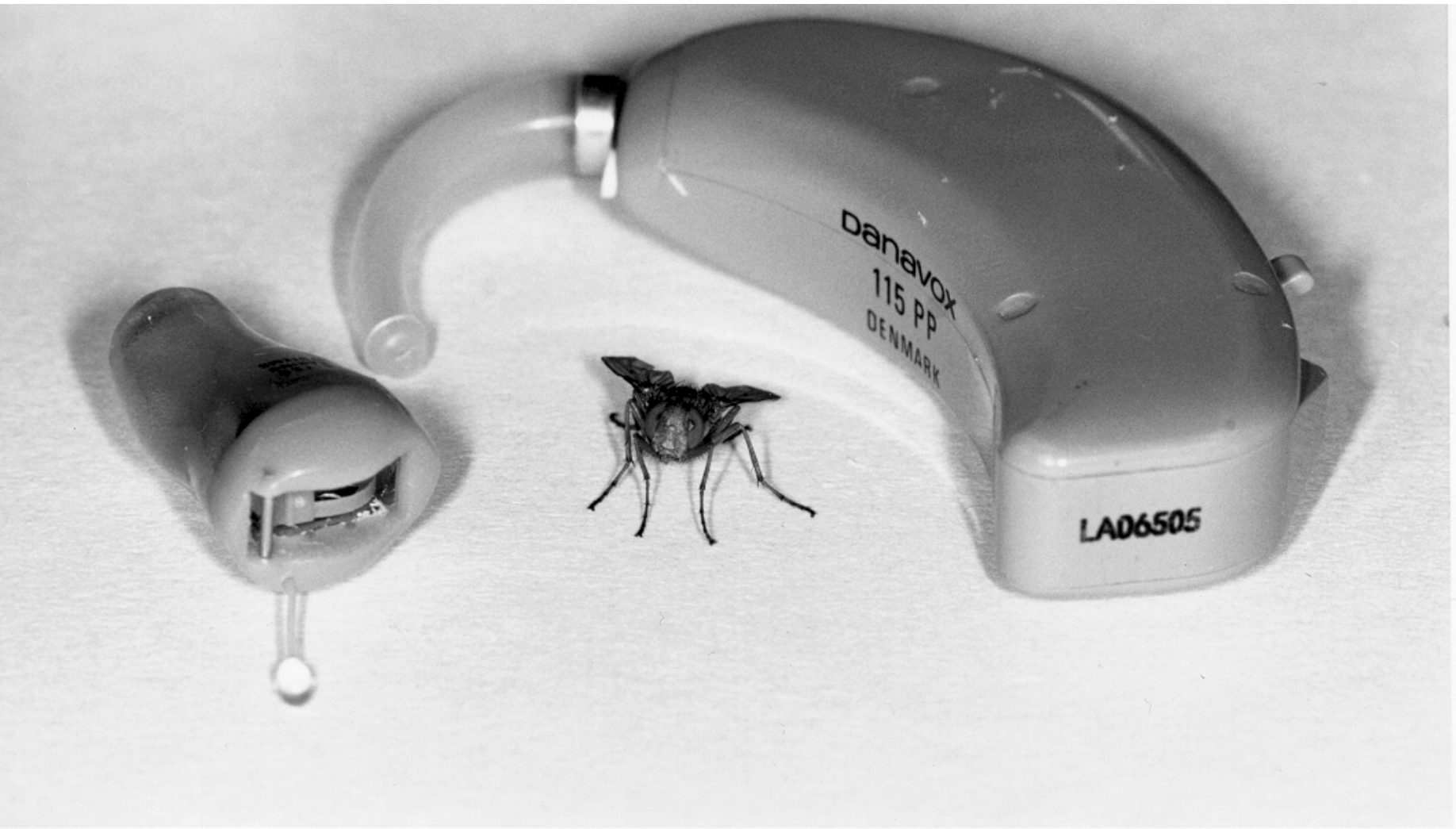
Highly Directional Two-Mode Sensor



Analytical Model Predicts Ear's Response



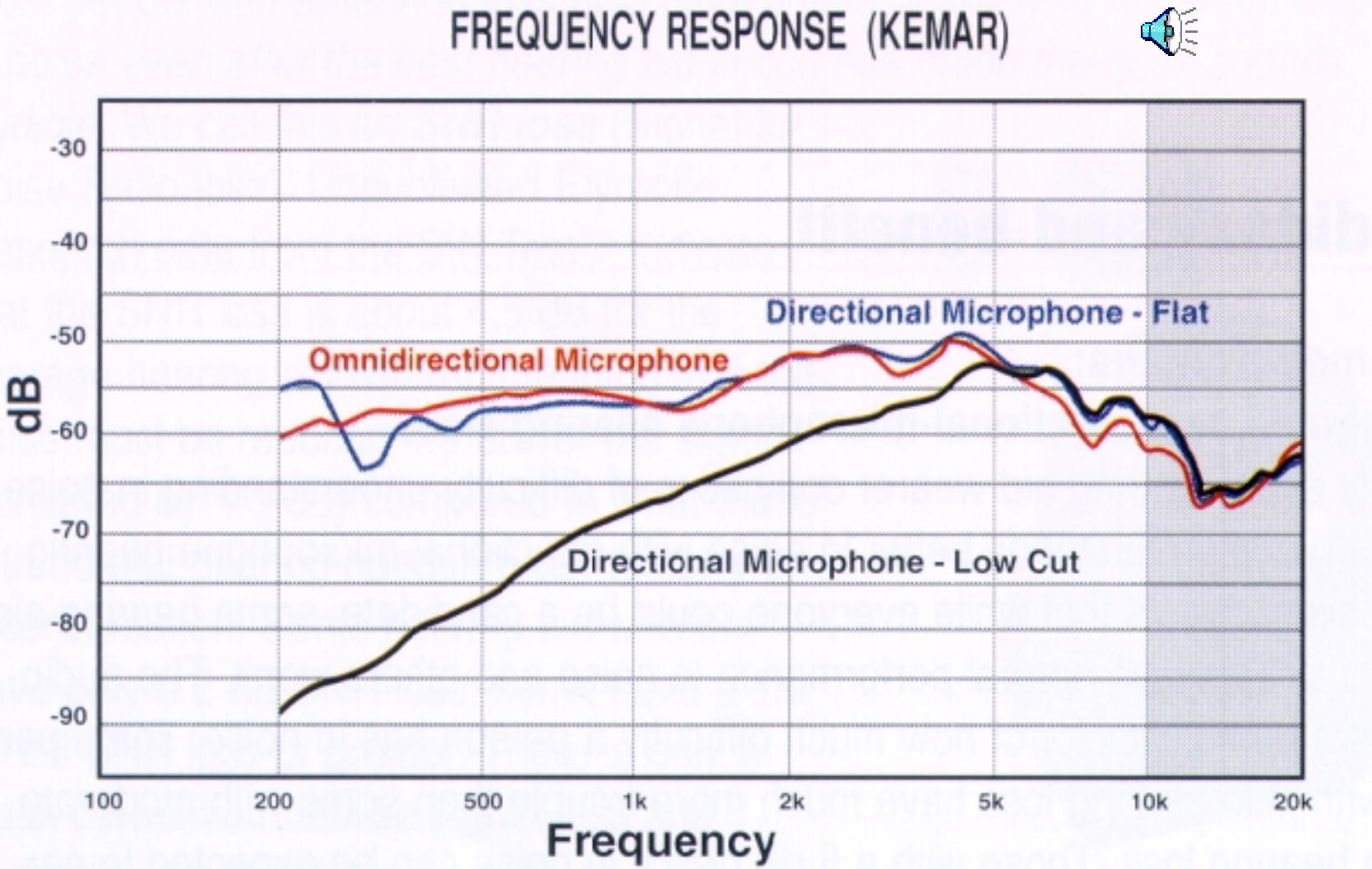
Application: Directional Hearing Aid Microphone



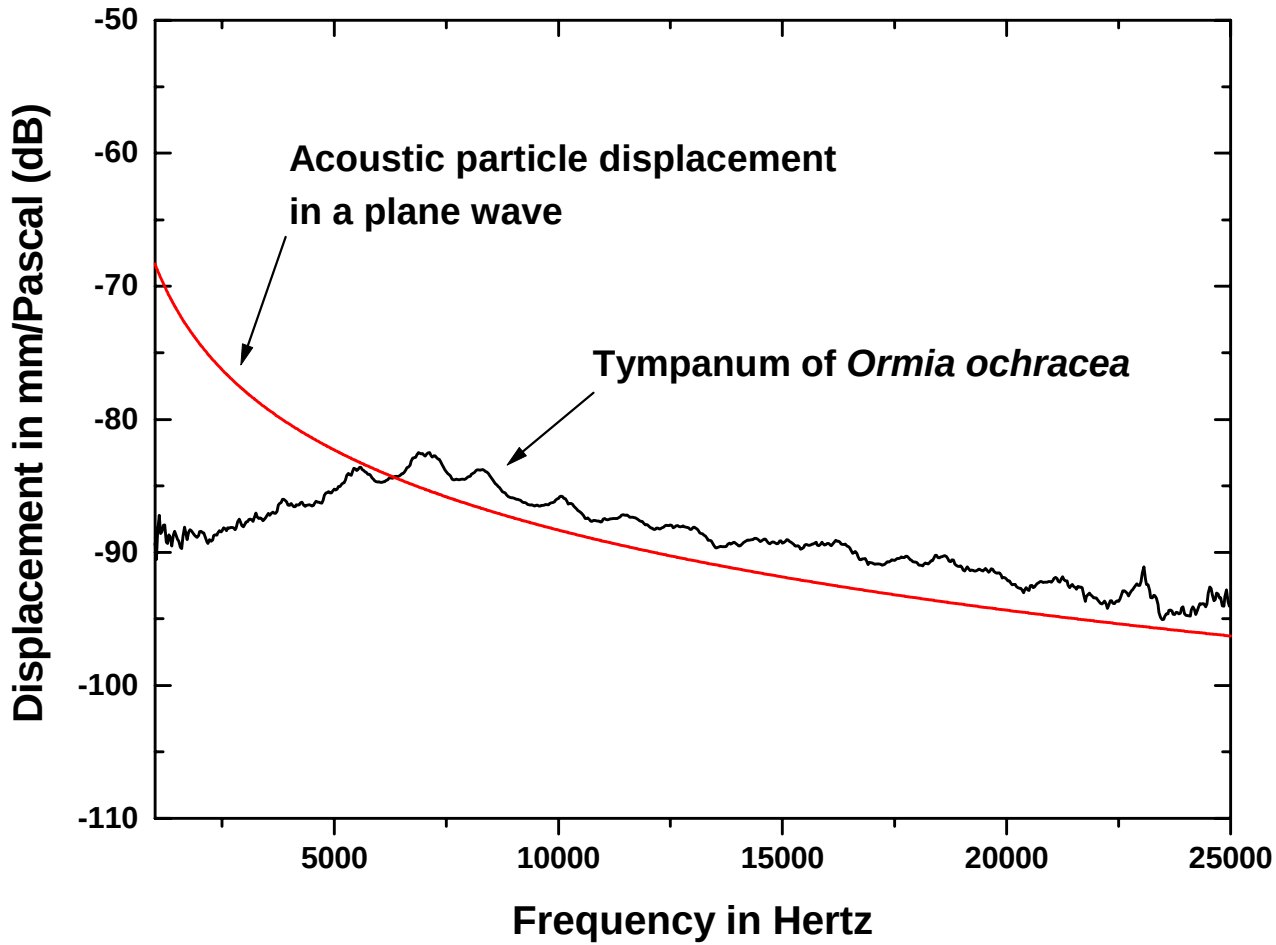
Etymotic D-Mic

ETYMŌTIC RESEARCH

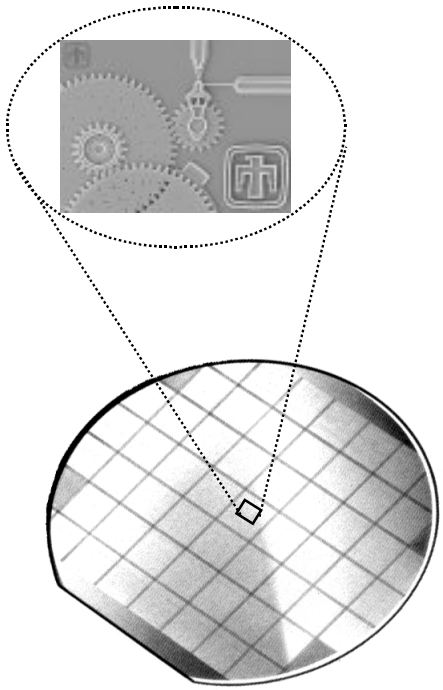
Measured Response of D-Mic



The Fly's Ear is a Sensitive Acoustic Sensor



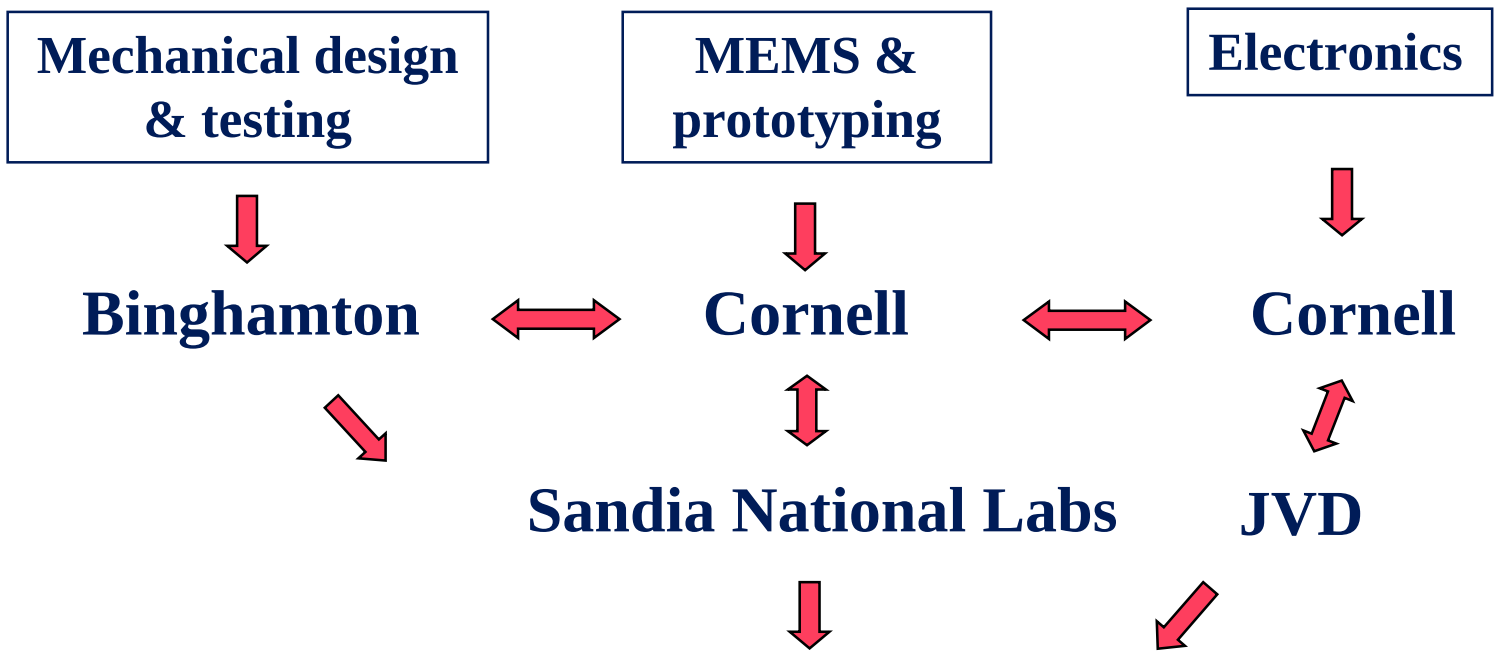
MEMS



- **Microelectromechanical systems**
- **Mechanical devices with integrated circuits on silicon**
- **Batch fabrication using silicon IC technology**
- **New solutions that are low-cost**

- **Can implement the fly's ear in a hearing aid using silicon MEMS technology**

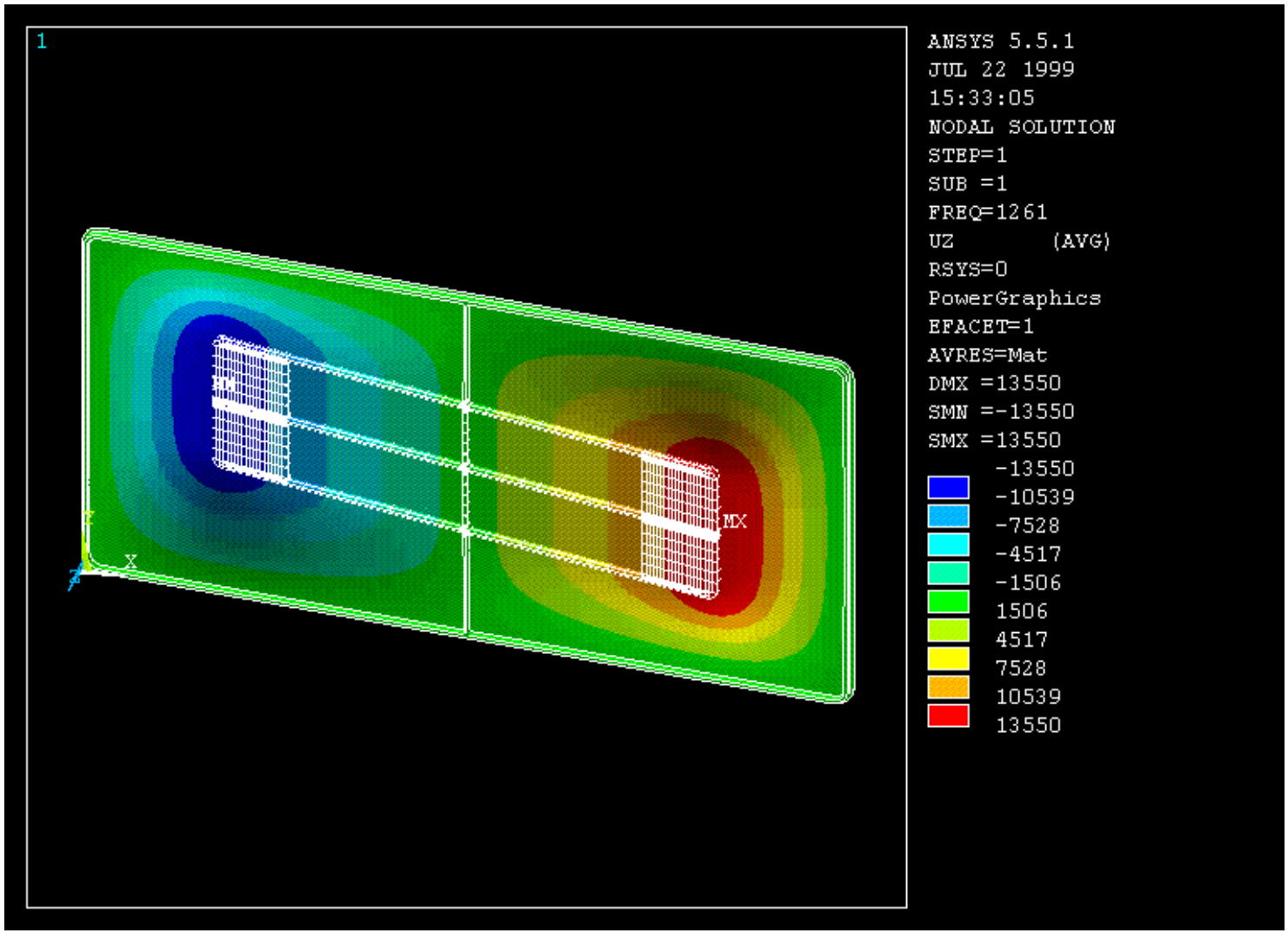
Team Organization



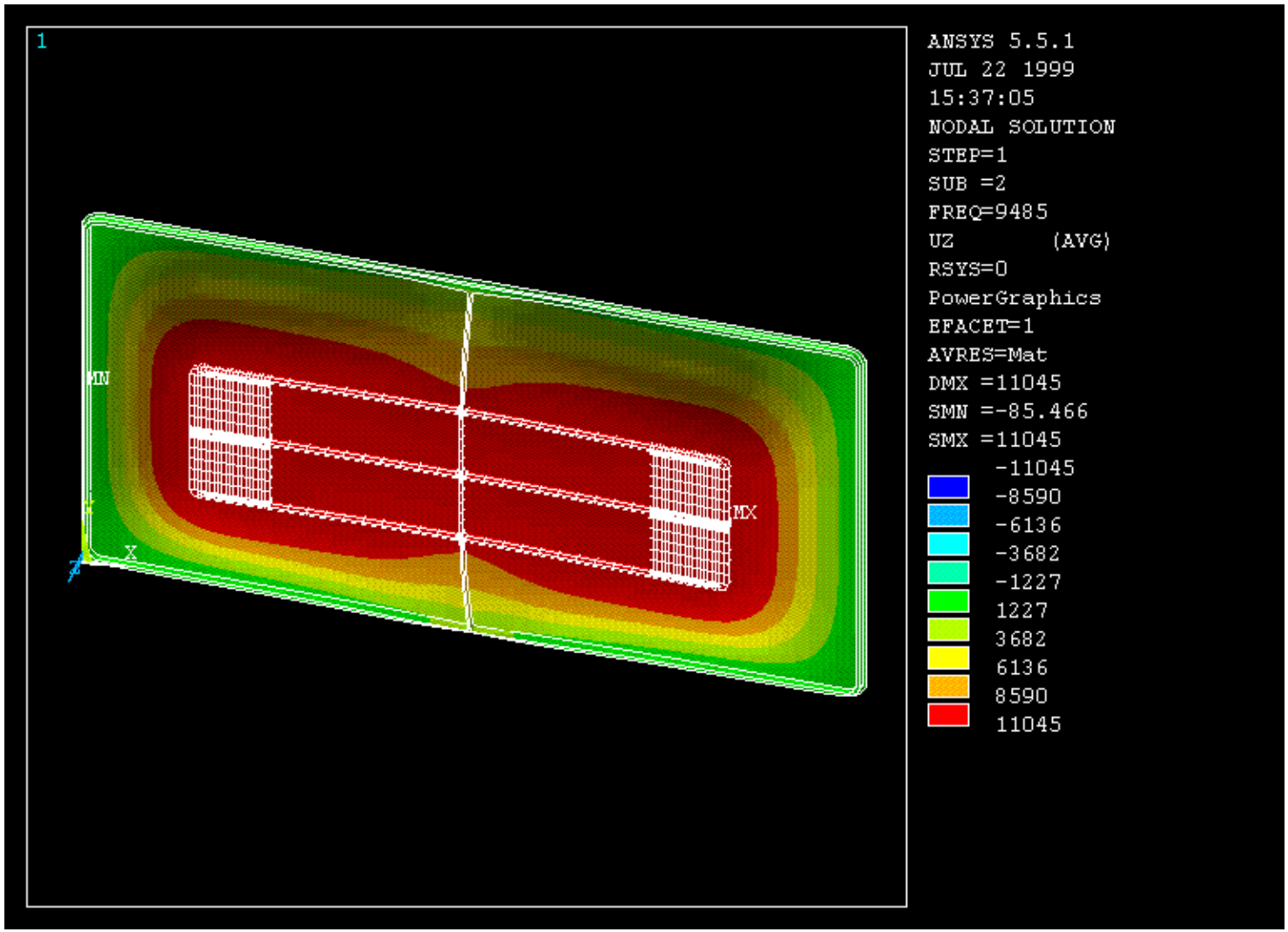
Consultants:
Bob Young
Ron Hoy

Toward commercialization

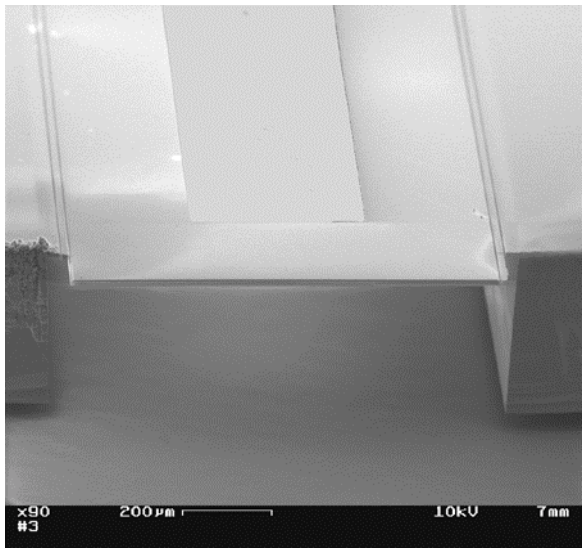
Membrane Design using FEM

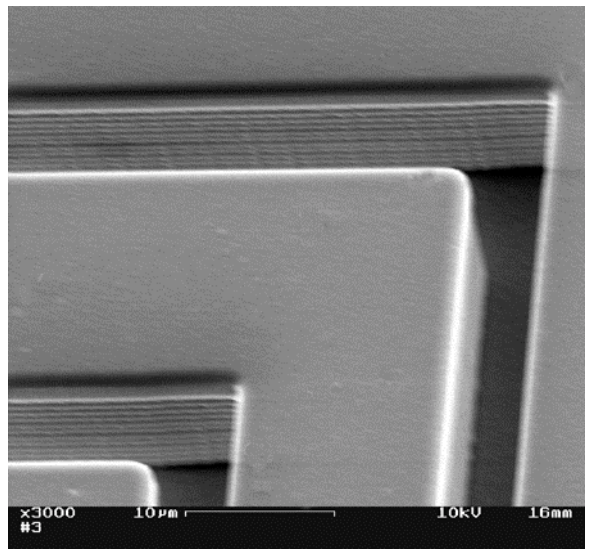


Membrane Design using FEM



Polysilicon membranes



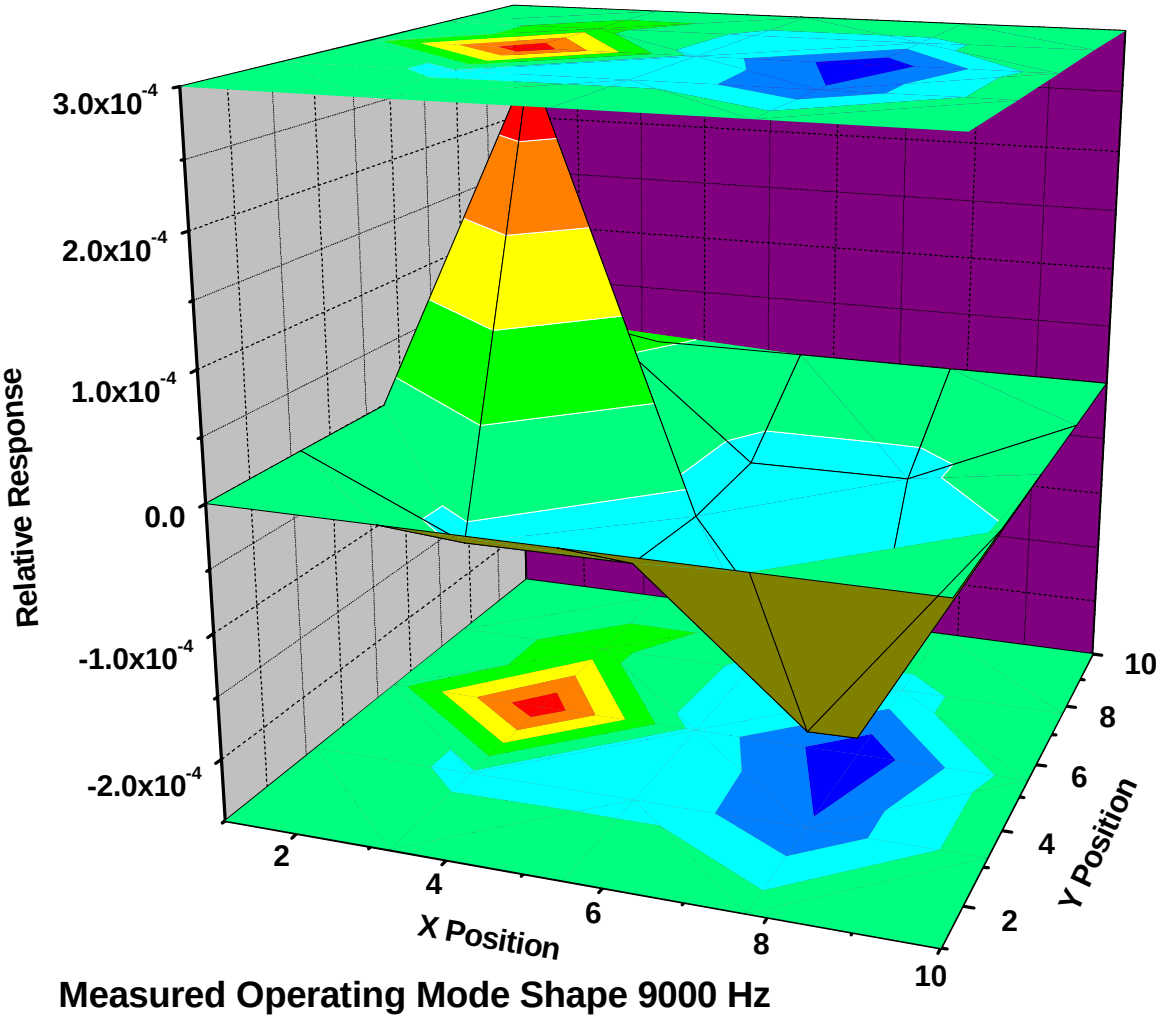


Close-up of the corrugation

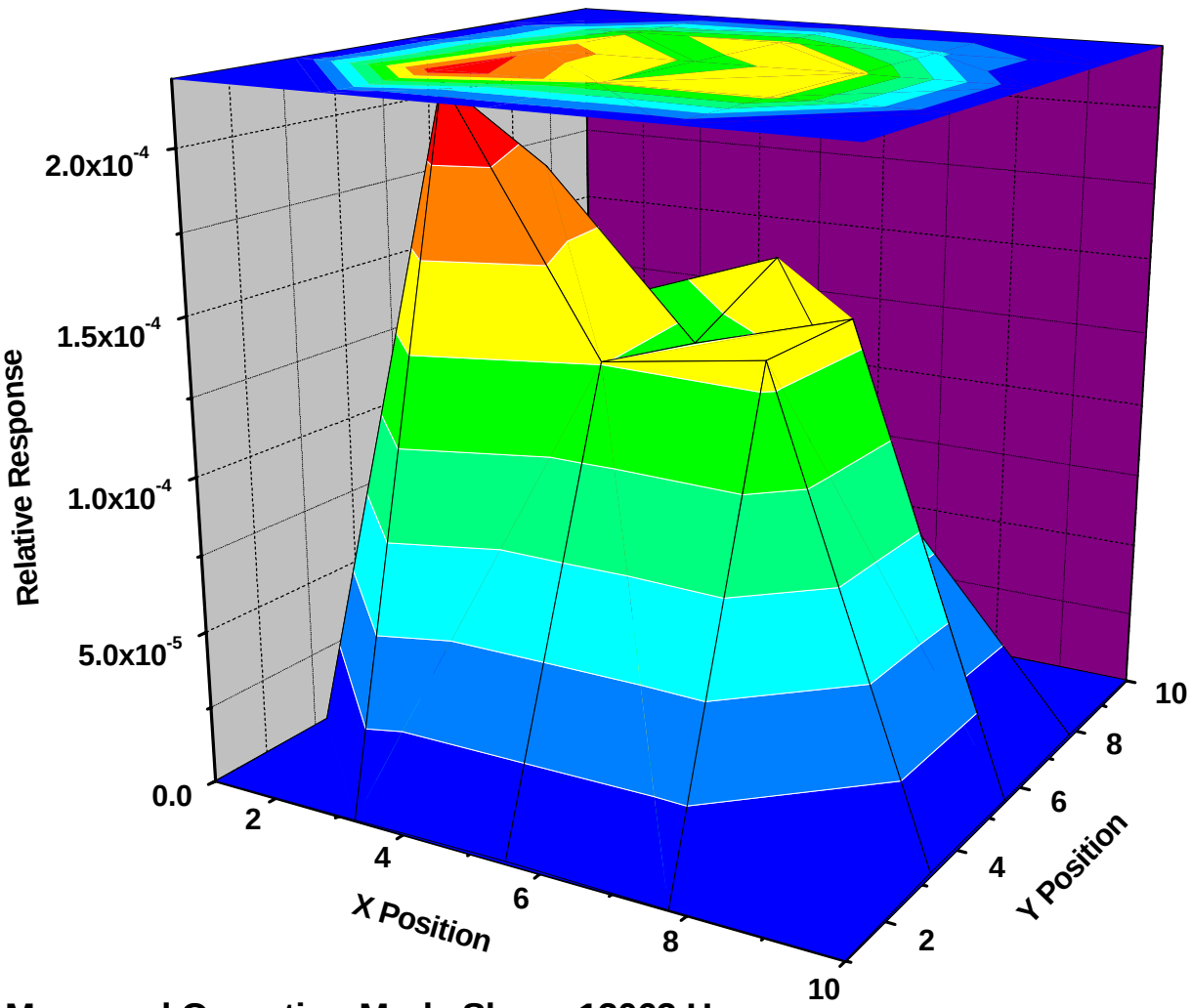
Cross-section of the 1.0 x 0.5 mm^2 polysilicon membrane. The membrane is 0.5 µm thick with 10 µm deep corrugations.

Measurement of Mechanical Sensitivity

Measured Anti-symmetric Mode



Measured Symmetric Mode

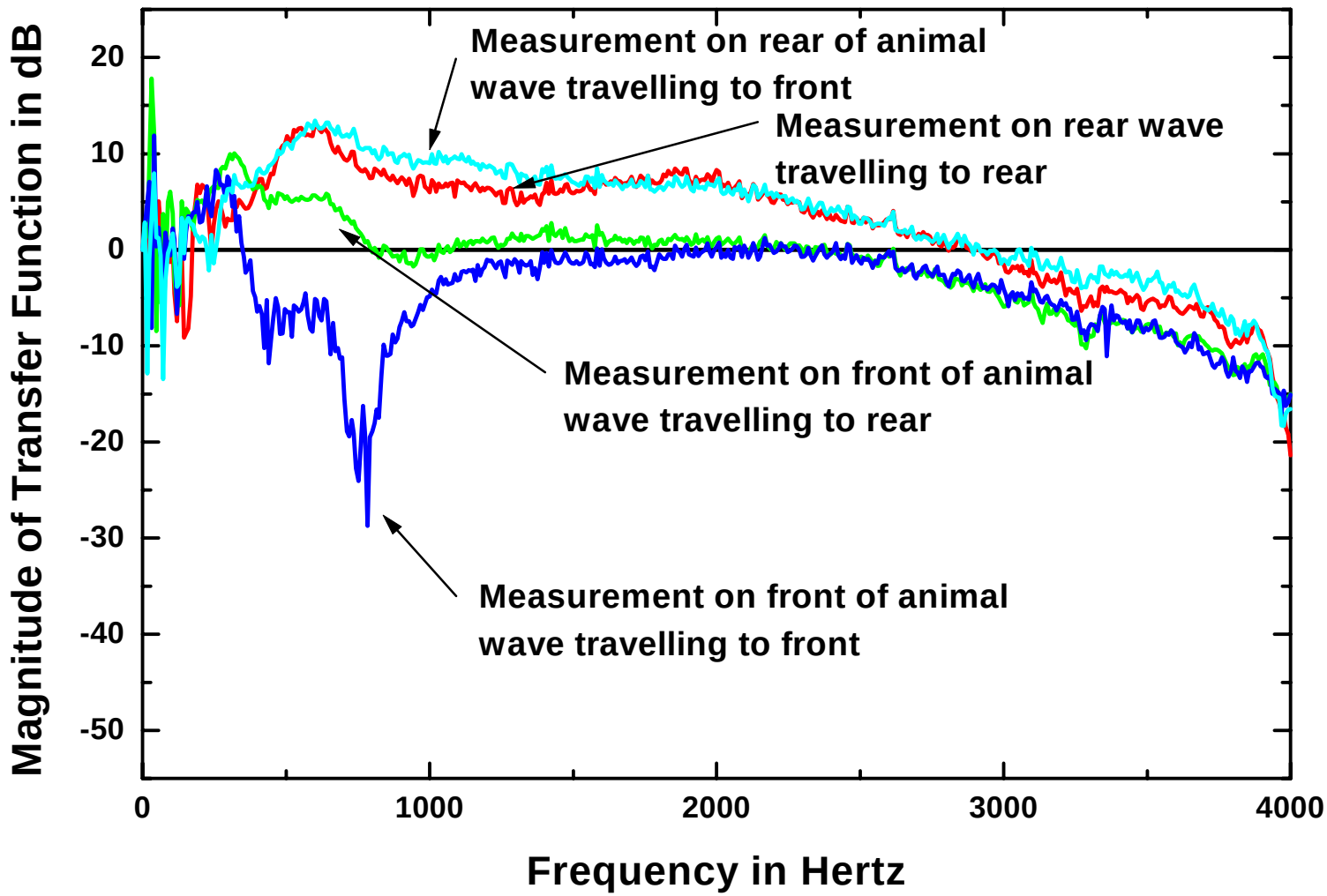


Measured Operating Mode Shape 13063 Hz

Vibrational Communication in a treehopper

Bending Wave Simulator

Vibration Depends on Wave Direction



Proposed Biomimetic Sensors

- Miniature acoustic particle velocity and pressure sensor for sound intensity measurement
- Higher-order miniature directional microphones- Passive, low-cost

References

[1] R. N. Miles, D. Robert, and R. R. Hoy 1995 *Journal of the Acoustical Society of America* **98**, 3059-3070. Mechanically coupled ears for directional hearing in the parasitoid fly *Ormia ochracea*.

[2] D. Robert, R. N. Miles, and R. R. Hoy 1996 *Journal of Companative Physiology* **179**, 29-44. Directional hearing by mechanical coupling in the parasitoid fly *Ormia ochracea*.

[3] R. N. Miles, T. D. Tieu, D. Robert and R. R. Hoy (1997), "A mechanical analysis of the novel ear of the parasitoid fly *Ormia ochracea*," in *Proceedings:Diversity in Auditory Mechanics*. E. R. Lewis, et. al. (Eds.), (World Scientific, Singapore), pp. 18-24.

[4] Robert, D., Miles, R. N. and Hoy, R. R. 1999 *The Journal of Experimental Biology* **202**, 1865-1876. Tympanal hearing in the sarcophagid parasitoid fly Emblemasoma sp.: the biomechanics of directional hearing.